

INTERIM REPORT
OF
THE SANITARY CONDITION
OF
THE ROYAL BARRACKS, DUBLIN,
BY
MR. ROGERS FIELD, M. INST. C.E.

Dated February 25th, 1889.

Presented to both Houses of Parliament by Command of Her Majesty.



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INTERIM REPORT

ON THE

SANTARY CONDITION OF THE ROYAL BARRACKS, DUBLIN.

TO THE RIGHT HON. EDWARD STANHOPE, M.P., SECRETARY OF STATE FOR WAR,
SIR,

IN accordance with the instructions which I received from you on the 20th November last, to make a thorough inquiry into the sanitary condition of the Royal Barracks, Dublin, I have paid three separate visits to Dublin, each of four or five days' duration, and have been carefully over the whole of the Royal Barracks and Arbour Hill, including the Hospital, Married Soldiers' Quarters, and the Prison. I personally examined the drainage and other sanitary arrangements, the nature and stratum of the sub-soil, the condition of the floors, and many other matters, and gave instructions to my Assistant for investigating various details.

I put myself into communication with Colonel Marsh, Commanding Royal Engineer in Ireland; Colonel Slacks, Commanding Royal Engineer in charge of the Dublin District; Major Lermine, Royal Engineer in charge of the Royal Barracks; and the Principal Medical Officer in Ireland; and received every assistance from them. I also obtained valuable assistance from Professor Hull, F.R.S., Director of the Geological Survey of Ireland; and from Sir Charles Cameron, Superintendent Medical and Executive Officer of Health for Dublin. In addition to this, I have had an Assistant for about a couple of months in Dublin investigating numerous details under my direction.

A thorough inquiry into the sanitary condition of the barracks includes so many different branches and, for reasons explained hereafter, it is necessary to go so exhaustively into many of them, that a large amount of time is necessarily required to follow them all up. I have consequently not yet been able to complete my investigation, but as you are particularly desirous of having an instalment of my Report, I have done my best to meet your wishes in the following pages, although I should have much preferred to postpone making any report at all till the whole of my investigation was complete.

I have acquainted myself as thoroughly as I could with what has already been done on the question of the sanitary condition of the Royal Barracks, and for this purpose I have studied and noted the numerous Reports and papers supplied to me, and looked up others referred to in them. This study was a tedious and troublesome matter, but it gave me valuable information, and convinced me that so much had already been done that it was necessary, for the proper understanding of the subject, to have a succinct statement of the history of the various inquiries about the Royal Barracks, and the action taken on them. Such a statement I will now proceed to give as briefly as I can, consistently with placing the facts clearly before you. The allusions to the various portions of the barracks will be better understood by referring to the plans attached to this Report.

Historical Statement.

According to information supplied me by Colonel Marsh, the Commanding Royal Engineer in Ireland, the original barracks were laid out in 1706, in the reign of Queen Anne. A plan of the buildings in 1756 shows them to be very much as they are at present, with two important exceptions, viz., there was no east side to Palatine Square, and the present Horse Square was not in existence. Shortly after this date the east side of Palatine Square was added, but Horse Square does not seem to have attained its present form until about 40 or 50 years ago.

The first Report I have come across as to the Royal Barracks (and it is an important one though brief) is contained in the General Report presented to Parliament in 1861 from the Commission for improving the condition of the Barracks and Hospitals. This Commission was appointed by the Secretary of State for War (Lord Panmure), in consequence of the recommendations of the celebrated Report of the Royal Commission of 1858, of which the Right Hon. Sidney Herbert was President.

Inter-
dicted)

Time not
sufficient to
complete the
investiga-
tion.

Reasons for
giving a his-
tory of the
various
inquiries.

Plans
attached.

Original
barracks,
1706-1756.

1861.
Report of the
Commission
for improv-
ing the
condition of
the barracks
and hospitals.

The Commission appointed by Lord Panmure sat for several years, and made personal examinations and detailed reports as regards a large number of barracks and hospitals. In their very valuable General Report a plan was given of the Royal Barracks, substantially as they exist at the present time, and the arrangement of the buildings was criticised by the Commission unfavourably. They stated that the buildings, although disposed with apparent regularity, were crowded together with dark narrow lanes between three and four storey buildings, without any outlet sufficient to prevent stagnation of air. The ground, moreover, rose rapidly behind the barracks, and there was no free circulation of air at the back. They concluded by stating that, "taken as a whole, the arrangements of this plan " afford an excellent illustration of what ought to be avoided in barrack construction."

In the Appendix to the General Report the Commission gave a number of detailed recommendations as to the improvements required at the Royal Barracks. These consisted chiefly of reduction of men so as to prevent overcrowding; the abolition of privies and substitution of waterclosets; provision of additional bath and ablution rooms; improvements in the drainage, in the water supply, in the floors, ventilation and lighting of the barrack rooms, also improvements in scavenging.

I know hardly anything about the history of the barracks for the next 18 years, but the recommendations of the Commission of 1861 appear to have been all carried out, with the exception of two comparatively small items which I shall have occasion to refer to hereafter. I also find that in the years 1876-8 a new system of main drains composed of stoneware pipes was constructed in lieu of the old masonry drains.

In 1879, in consequence of the occurrence of enteric fever, principally amongst the cavalry officers, an inquiry was held by a Board of Medical Officers as to the sanitary condition of E. and F. houses, Cavalry Square. In their Report, dated 10th November 1879, the Board stated that for several years past cases of enteric fever frequently occurred in E. and F. blocks, more particularly in the small centre-partitioned rooms, and they recommended that the whole of the flooring in the basement should be taken up, the ground examined for old drains and then concreted, and ventilation established between the flooring and the concrete, that the small centre-partitioned rooms should be removed, and that a watercloset in the upper storey of the adjoining block (Q. house, Royal Square) should be removed, and a dry area constructed round the blocks.

In consequence of further cases of fever in 1880, the Army Sanitary Committee made a careful inquiry and Report on the sanitary condition of the Royal Barracks. The Committee had the Quartermaster-General, Lord (then Sir Garnet) Wolseley, for president, and amongst its members several eminent sanitarians, such as Sir Douglas (then Captain) Galton, Dr. Sutherland, Sir Joseph Fayrer, and Sir (then Mr.) Robert Rawlinson. Sir Douglas Galton visited Dublin and made an inspection of the barracks, and an independent report and three other reports were drawn up on the spot (by the Commanding Royal Engineer, the Principal Medical Officer, and a Special Sanitary Board in Dublin) for the purpose of the inquiry.

In the Report dated April 1881 the Committee went into the whole question very thoroughly as regards the prevalence of fever in the barracks compared with that in Dublin, the water supply, the milk supply, the local conditions in the immediate vicinity of the buildings where the fever occurred, and the general structural conditions of the Royal Barracks.

They stated that past experience showed that the occurrence of enteric fever among the troops in Dublin bore some relation to the intensity of the disease among the civil population, and that the special returns prepared for them by the Registrar-General for Ireland seemed to show that a relation of this kind also existed in the case of the recent outbreak at the Royal Barracks. They also stated that it was worthy of note that all the cases of fever in 1879-80, with one exception, took place in the officers' quarters and not in the soldiers' barrack rooms, a circumstance which might possibly be due to the improvements carried out in these rooms in consequence of the recommendations of the Barracks and Hospitals Improvements Commission, 1861, whereas the officers' quarters were not included in the instructions issued to that Commission.

The Committee found that there were defects of drainage or ventilation in all the houses where illness had occurred, but that in one house only (the Major-General's quarters in

Their
opinion as
to Royal
Barracks.

Recom-
mendations
as to im-
provements
required
there.

1861-78.
Recom-
mendations
carried out,
and new
system of
drains
constructed
in 1876-8.

1879.
Inquiry by a
board of
medical
officers.

1881.
Inquiry by
the Army
Sanitary
Committee.

Abstract of
Report of
Army
Sanitary
Committee

Royal Square) the defects were serious, and sufficient to account for the illness; that each block of the officers' quarters in Cavalry Square was unwholesomely crowded, on one side either by other barracks or by cook houses, waterclosets, and low class buildings; that the new drains had been improperly laid in the old masonry drains, which were perforated by rats and surrounded by saturated ground, and that the paving was to a large extent cobble stone paving which prevented the pollution by the horses being properly cleaned. They also considered that the age of the buildings and rotteness of the woodwork contributed to make the quarters unhealthy. The Committee added there was a general concurrence of opinion in which they agreed that the Royal Barracks were a bad sample of barrack construction, and that considerable portions of the buildings should be removed in order to secure light and ventilation to the remainder.

The conclusions the Committee arrived at were:—

- (1) The clue to the occurrence of enteric fever in the Royal Barracks was to be found in its prevalence at the time as an epidemic in Dublin and in the vicinity of the barracks, together with the foul condition of the tenement and other houses in Temple Street immediately on the west side of the barracks.
- (2) The quarters where it appeared, although all inhabited by officers, were about the most likely portions of the whole establishment for fever cases to occur.
- (3) The causes why officers' quarters were attacked were partly general, arising from impure air of the Cavalry Division, but mostly local, arising from defects in drainage and ventilation.

Conclusions
of the Army
Sanitary
Committee.

The Committee recommended, in the case of the officers' quarters, improvements in the drainage, concreting underground floors, renewal of floors, scraping of walls, throwing down partitions, and additional ventilation. For the barracks generally they recommended the removal of old masonry drains in which pipe drains were laid and the preparation of a plan for removing and reconstructing portions of the barracks; they also considered it very desirable that the bad class of property in Temple Street adjoining the barracks should be removed.

Recommendations
of the Army
Sanitary
Committee.

In consequence of this Report of the Army Sanitary Committee the then Commanding Royal Engineer prepared a Report and plan showing certain demolitions which he advised to be made, the chief features being the removal of the riding school and other obstructing buildings to the north of the barracks and forming openings in the sides of the Royal and Palatine Squares so as to admit more light and air. In his Report he went thoroughly into the re-appropriation and new buildings which would be required, and stated that he considered the acquisition of the property between the barracks and Temple Street the most important step which could be taken towards improving the sanitary condition of the barracks.

Commanding
Royal
Engineer's
Report as to
proposed
demolition.

No action was taken with reference to the demolitions, but after these Reports extensive sanitary improvements were made in the barracks, the drainage was revised, especially that of the officers' quarters, which was found to be defective, the pavement was improved, the stables were improved, ground floors of the buildings were excavated and concreted, dry areas constructed round many of the buildings, the ventilation was improved, and the rooms in Palatine Square were enlarged by throwing the corridors into them. The extensive nature of the alterations may be judged from the fact that the expenditure on sanitary improvements during the six years 1881 to 1886 was about £1,000.

1881-86.
Demolitions
not carried
out, but
extensive
sanitary im-
provements
made.

In 1886 there was a considerable outbreak of enteric fever in other parts of the barracks, as well as in the cavalry officers' quarters, and special investigations and reports were made as to the sanitary condition of the barracks by the Principal Medical Officer, the Commanding Royal Engineer in Ireland, the Commanding Royal Engineer, Dublin District, and the Royal Engineer Division Officer. These Reports contained a great number of suggestions as to the probable cause of the unhealthiness of the barracks, the following being the principal ones:—

1886.
Outbreak of
enteric fever.
Reports by
Medical and
Engineer
officers.
Suggestions
as to pro-
bable causes
of unhealthi-
ness.

- Crowding of the buildings so as to obstruct light and air.
- Hemming in of the barracks by inferior buildings on western side (Temple Street).
- Overcrowding of men and horses.
- Insufficient ventilation of the drains.
- Forcing back of foul air into the drains by the rising of the tide and consequent forcing of traps.
- Undiscovered defects in the sewers and drains.
- Accumulation of polluted subsoil water under the barracks.

Polluted state of the River Liffey, especially opposite the barracks, which is the limit of tidal action.

Vatry water sometimes unsatisfactory.

Slight defects only discovered in the drainage.

Analyses of the Vatry water.

Remedies suggested.

H.S.H. Com- manding Forces in Ireland recommended removal of cavalry barracks.

1847. Inquiry and Report by Board of officers.

Cavalry officers' quarters vacated in February 1887.

Sir Robert Rawlinson's report, suggesting sanitary defects.

Reply of the Royal Engineer in charge of the barracks.

Suggestions that the cause of disease might be in the floor-boards and walls.

Further investigations.

May 1887. Appointment of Sir Charles Cameron's Commission.

From the various Reports it appears that the investigations disclosed certain slight defects in the drainage, but that nothing was discovered in any way sufficient to account for the illness. It was also stated that the rising of tide did not force the traps. Analyses were made of a number of samples of the Vatry water taken from the Royal Barracks, and a special investigation was made to ascertain whether there were any defects in the water pipes which would account for local contamination. Analyses were also obtained of the Vatry water from other localities for the purpose of comparison, but no local contamination was discovered.

The remedies suggested were the removal of the partitions which formed small rooms or hanks in the officers' quarters; certain small improvements in the drainage; and some rather extensive demolitions so as to give more light and air. The chief features of the demolitions were, the removal of the riding school, the forming of certain openings in the sides of the square and the opening up of the ends of the dark narrow lanes between the squares. A complete system of subsoil drainage was also recommended at a cost of 1,200*l*.

His Serene Highness commanding the forces in Ireland reported that he considered that the cavalry officers' quarters were subject to some obscure cause of fever, and that he concurred in the opinion of his predecessor, Sir T. Steele, that the cavalry barracks should be removed altogether.

Early in January 1887, a Board of Officers was convened to report on the sanitary condition of the cavalry officers' quarters. They made examinations, took evidence, and reported that the officers' quarters were without doubt in an unsanitary condition, but that the Board had been unable to ascertain the cause, none of the defects of drainage discovered being in their opinion sufficient to account for the undoubted sickness experienced by so many of the occupants. The Board considered that the unhealthy condition was probably due to local causes which could only be ascertained by extensive excavations, and recommended that the cavalry officers' quarters should be at once vacated and not again occupied until the cause had been fully ascertained and remedied.

In consequence of this Report the Cavalry officers' quarters were for the most part vacated in February 1887, and have not been occupied to the present time (February 1889). It may be as well also to state here that excavations were made round the blocks in accordance with the recommendations of the Board, but no trace of anything likely to affect the health of the inmates was discovered.

A Report was also made by Sir Robert Rawlinson suggesting that the evils were not so much in the site or general arrangement of the buildings as in sanitary defects of the quarters complained of. The quarters may not be cut off from the main sewers as completely as they should be, the sanitary appliances may be defective, the water may be in fault by connection of soil-pans to water mains, the main drains may be imperfect, and the subsoil may be water-logged. To this the Royal Engineer in charge of the barracks replied that the quarters were fully and completely cut off from the main sewers, the sinks and waterclosets were not in any way defective, the soil-pans were not connected to water mains, the main drains were not imperfect, having been reconstructed on the most approved principle, the subsoil was not water-logged, but was generally a clean dry gravel.

Subsequently a Report was made by the Commanding Royal Engineer stating that it would be seen from his previous Reports that the disease could not be traced to any definite defects, and that he was forced to the conclusion that the cause might be the existence of germs of disease in the floor-boards and walls. He, therefore, recommended the renewal of the floors and skirtings, cleaning and limewashing the spaces below the floors, scraping and washing walls and painting woodwork. He also again recommended subsoil drainage round each block, and the surface to be covered with concrete.

Further investigations were made, including taking out the grates to see if there was any accumulation of foul soot, but nothing was discovered. The question was also gone into as to the particular floors on which the different cases of fever occurred, and it was found that most cases occurred on upper floors.

In May 1887, a Commission was appointed consisting of Sir Charles Cameron, Superintending Medical Officer of Health for Dublin, and Dr. Grimshaw, Registrar-General in Ireland, to report on the prevalence of enteric fever in the Royal Barracks. The Commission went fully into the questions of the site of the barracks, plan and structure of buildings,

sewers, drains, closets and latrines, water supply, milk supply, impurities of the air, prevalence of disease and mortality in the Royal Barracks as compared with that in other barracks and with that among the civil population, and the special distribution of the disease in the Royal Barracks. The Commission made a preliminary report in August, and their complete Report in November 1887, and both were presented to Parliament early in 1888.

The conclusions of this Commission may be summarised as follows:—

Conclusions
of the Commission.

That the prevalence of fever at the Royal Barracks did not correspond with that among the civil population in Dublin, and that local causes existed which maintained the disease independently of its general prevalence in Dublin.

The great bulk of the cases were grouped in three localities, viz.:—

- (1.) Cavalry Square.
- (2.) West side of Royal Square.
- (3.) West side of Palestine Square.

The remaining cases were scattered and were only such as might occur in the vicinity of groups of cases.

The primary causes of the fever in the cases in locality (1) were defects in the drainage arrangements in the vicinity, aggravated by the passage down the drains of the excreta of the enteric fever patients in the Arbour Hill Hospital.

The primary causes of the fever in the cases of localities (2) and (3) (which may be mentioned together, as the conditions are similar) were insufficient light and air, due to the crowding together of the buildings, aggravated by the defective form of latrines used in common by all the men.

There were other subsidiary causes of the unhealthiness of the barracks, such as saturation of subsoil, defective state of floors, defective drainage arrangements, want of proper administration with reference to removal of refuse and other similar matters, bad ventilation of barrack rooms, unsuitable hospital accommodation, and transference of fever patients from one barrack to another. The milk also was suspected of being a source of mischief.

The Commissioners made a number of recommendations, which may be summarised as follows:—

Recommendations
of the Commission.

Removal of a considerable portion of the present buildings, the lowering of high walls and sloping of banks to let in light and air.

Provision of a separate drain for the Arbour Hill Hospital, testing and remedying of defects in drains of the barracks generally, and improving the method of ventilating the drains.

Substitution of improved water-closet apparatus for the men.

Provision of a complete system of subsoil drainage and covering of ground likely to be polluted with impervious material.

Renewal of defective barrack room floors and the rendering of all floors impervious, to prevent saturation by washing.

Improving the ventilation of the barrack rooms.

Better arrangements for the removal of dust and other refuse.

Care to be taken with reference to the milk supplies.

Disuse of Arbour Hill Hospital for infectious diseases and the provision of a new hospital

After the receipt of the Report of this Commission the War Office, as you are aware, authorised the greater number of the recommendations to be carried out, and they were consequently put in hand. Most of the authorised items were completed last year except the provision of a new hospital for infectious diseases, which has only just been arranged.

Most of the recommendations carried out.

As regards the extensive demolitions, however, recommended by the Commission, comparatively little has been done, as although all the authorities agreed that demolitions were required, there was a considerable difference of opinion as to the precise buildings which ought to be removed. It was also considered that there would be great objections to any extensive demolitions being carried out until the new barracks at Grange Gorman, now in course of construction, were completed so that proper quarters might be provided in place of those destroyed. The result of this divergence of opinion was that the only demolitions that were ordered were the removal of the obstructions at the ends of the dark lanes between the squares, and of the urinals, wash-houses, and cook-houses in these lanes, which, although undoubted improvements, were trifling in comparison with the large demolitions recommended by the Commission. There are also two or three other recommendations which have not been carried out. These I shall have occasion to refer to hereafter.

Demolitions not carried out, except in a few cases.

This brings me to the end of my review of the history of the subject, which has extended to a greater length than I anticipated, but which I have found it impossible to shorten consistently with giving a fair account of the matter. It only remains to be stated that,

Notwithstanding recent sanitary

improvements, cases of fever have increased and extended.

notwithstanding the sanitary improvements which have recently been made, the cases of fever have increased in number, and have extended to many portions of the buildings, instead of being practically confined to three localities, as they were previous to the time of Sir Charles Cameron's Commission. This extension has altered the basis of some of the conclusions of the Commission which rested on the limited area of the outbreak. The question has, therefore, again been re-opened, and has occupied considerable attention; further analyses and biological investigations have been made of the water and a whole host of suggestions have appeared in newspaper correspondence and articles, most of which, however, are mere repetitions of what has been suggested before.

Conclusions that may be drawn from history of subject.

The following conclusions may be drawn from a careful study of the various reports and documents referred to in the previous review of the history of the subject:—

- (1.) There have been numerous inquiries and Reports into the sanitary condition of the Royal Barracks by competent persons, including two Commissions, the Army Sanitary Committee, two Boards of Officers, and a large number of Royal Engineers and Medical Officers, and nearly every conceivable phase of the subject has been dealt with, and many phases inquired into over and over again.
- (2.) Enteric fever has prevailed at the Royal Barracks for many years past, at first almost exclusively amongst the officers in Cavalry Square, and afterwards amongst the rank and file, as well as the officers, in different portions of the barracks, and the number of cases has largely increased during recent years.
- (3.) At first the prevalence of fever in the Royal Barracks appeared to correspond to some extent with its prevalence among the civil population in Dublin, but in recent years this correspondence appears not to have existed.
- (4.) In consequence of the recommendations at the various inquiries, extensive sanitary improvements have been made from time to time in the Barracks—the outlay on sanitary works during the last 10 years having been upwards of 17,000*l.*—but these improvements, unfortunately, have not been attended with a corresponding improvement in the health of the Barracks.
- (5.) The defects which were discovered in the drainage and other sanitary arrangements at the various inquiries during the last ten years have been comparatively few, and rarely sufficiently grave to account for the large amount of illness.
- (6.) There is a remarkable concurrence of opinion that the buildings at the barracks are crowded together, and that demolitions are required to give more light and air.
- (7.) There is also a concurrence of opinion that the Riding School and some other structures to the north of the barracks should be amongst the buildings to be removed, but as to what the other demolitions should be there is a great difference of opinion.
- (8.) As regards the many other questions which have been inquired into there are conflicting statements and puzzling differences of opinion, questions being apparently settled at one time and then re-opened at another.

Scope of present Inquiry.

The study of the history of the subject has convinced me that the only satisfactory way of dealing with it is to investigate the various doubtful questions as thoroughly and exhaustively as possible, so as to set at rest, once for all, the various conflicting statements and suggestions, and this is the principle on which I have acted.

The inquiry resolves itself into at least the following branches, all of which require to be considered more or less thoroughly:—

- Drainage and sanitary appliances.
- Nature and stratification of subsoil.
- Condition of surface and subsoil as regards pollution.
- Crowded arrangement of buildings.
- Structure of buildings.
- Condition of floors and spaces underneath them.
- Ventilation of buildings.
- Water supply.
- Milk supply.

Some of the branches involve chemical and biological investigation, and for these I have obtained the assistance of Dr. Dupré, F.R.S., and Dr. Klein, F.R.S.

As already stated, I have not had time to complete my investigation; in fact it is not sufficiently advanced for me to give the results arrived at about more than two of the branches, viz. :—Drainage and Sanitary Appliances; and Nature and Stratification of Subsoil.

Branches into which the inquiry resolves itself.

Drainage and Sanitary Appliances.

My investigation has been most thorough and complete, nothing having been left to conjecture. Every drain of any importance has been opened up for examination in one or more places, and on many drains a number of openings have been made, the total number of such openings being upwards of 150. In a great number of places the excavation was continued beneath the drain so as to ascertain whether the pipes were properly jointed. The smoke test was also applied to many portions of the drains. Besides the information thus gained as to the structure and condition of the drains, further information was obtained by flushing every drain separately with water, and noting the speed at which the water travelled, and whether or not it brought any deposit along with it.

I have prepared a plan of the Barracks and the Arbour Hill property showing the drainage in detail as ascertained by my investigation, and have also prepared a numbered schedule referring to the plan, indicating in detail the particulars of every drain, gully, manhole, ventilating-pipe, soil-pipe, water-closet, sink, bath, cistern, &c., and am sending a copy of these documents to the Commanding Royal Engineer in Ireland. A copy of the drainage plan on a smaller scale is appended hereto, and marked (I).

It will be seen from this plan that there are five separate systems of drainage, with five Main Drains (numbered 1, 2, 3, 4, 5 on plan), all of which discharge either directly or indirectly into the River Liffey.

Main Drain No. 1 takes the drainage from the north and east side of Palatine Square, and discharges into the corporation sewer in Liffey Street, which latter empties into the River Liffey.

Main Drain No. 2 at its upper end takes the drainage from the military prison and school at Arbour Hill, then crosses under the Arbour Hill Road to the barracks, passes down the lane between the Palatine and Royal Squares, crosses the Esplanade, and discharges into the River Liffey.

Main Drain No. 3 at its upper end takes the drainage from the married soldiers' quarters, the governor's house, and other buildings at Arbour Hill, passes under the Arbour Hill Road to the barracks, down the lane between the Royal and Cavalry Squares, under the Esplanade, and discharges into the River Liffey.

Main Drain No. 4 at its upper end takes the drainage from the infirmaries, Provost Prison, and other buildings at Arbour Hill, passes under the Arbour Hill Road to the Barracks, down the lane at the west side of Horse and Cavalry Squares, under the Esplanade, and discharges into the River Liffey.

Main Drain No. 5 (shown by dotted red lines on plan) at its upper end takes the drainage from the Arbour Hill Hospital only, passes under Arbour Hill Road, down the lane on the west side of Horse and Cavalry Squares, alongside the Main Drain No. 4, and discharges into it in the Esplanade below the "disconnecting" trap. This hospital drain, which has recently been constructed in accordance with the recommendations of Sir Charles Cameron's Commission, although passing down through the Royal Barracks, has no connexion with the drainage of the barracks.

It will be seen from the plan that, with a few unimportant exceptions, the whole of the drains are laid outside the buildings. This is a most important and advantageous feature, doing away, once for all, with the sanitary risks which must always more or less exist where drains pass underneath occupied buildings.

The exceptions to the drains being outside the buildings are one drain crossing under a stable, and two or three others under detached buildings, such as wash-houses and water-closets. As there is a barrack room above the stable, the drain under it was carefully tested by plugging it and filling it with water, when it was found to be perfectly water-tight. The stables themselves have no drains, but only open channels which discharge into gullies outside.

With very few exceptions, all drains are constructed of stoneware pipes, varying from 4 inches to 18 inches in diameter, the larger size being in excess of what is required. The few drains which are not constructed of stoneware pipes are of masonry with rounded brick inverts, and are in good condition. These masonry drains are shown on the plan in double lines.

The stoneware pipe drains are jointed with cement, and appear to be well and truly laid. It was stated in the Report of the Army Sanitary Committee, 1881 (see *ante*, page 5) that the new stoneware pipe drains were improperly laid in the old masonry ones, which were surrounded by saturated ground; but this appears to have been altered since that date, as in only one case has any portion of a pipe drain been found to be laid in the bottom of an

Drainage.
Numerous openings made to drains.

Smoke test applied and drains flushed to ascertain speed.

Plans prepared showing the drainage in detail, and a schedule referring to the plan.

Description of main drains.

With a few exceptions all drains laid outside buildings.

Drains are of stoneware pipes except in a few cases.

old culvert, and in this case the ground under the bottom of the culvert (a brick one) was clean and dry.

Defects discovered in drains.

Considering the large number of drains and their great extent, very few defects have been found in them, one of these only being serious.

This serious defect was on the line of Main Drain No. 1, at the east side of L House, Brunswick Square. Here the drain had been laid over an old disused cesspool, which had been filled in with clean earth and brick rubbish. The drain pipes had been laid immediately on the rubbish, without any other support, the consequence being that the rubbish had settled and let the drain down, so that the joints had opened and allowed some sewage to escape into the ground. This defect was remedied as soon as discovered, and the drain is now sound. It is worthy of notice, however, that not far from the point in question a case of illness occurred in M House (that of the Assistant Adjutant-General) in 1887.

The other defects were as follows:—

In Arbour Hill a portion of the main drain opposite the infirmary stables was found to be crushed at the top, owing to its being laid too near the surface, so that heavy carts passing over it cracked the pipes. The bottom of the drain, however, was sound, so that the sewage flowed properly.

In another case in Arbour Hill, at the Prison, a good brick drain which only took surface water was connected in an improper way to a pipe drain, so that the brick drain was full of deposit.

Two subsidiary drains from outside waterclosets in Arbour Hill were found to be laid with hardly any fall, and were choked with sewage.

In another place, where two different sized pipes joined, the connexion was formed by rough brickwork instead of by a proper taper pipe.

In the manhole on the north side of the Esplanade on drain No. 2, the bottom of the pipe was found to have a large hole in it, probably made by some heavy substance which had been dropped into it.

Some of the above defects have been repaired.

Though drains appear to be sound, there are reasons to suspect undiscovered defects.

Judging by the results above given, the drains would, according to all ordinary methods of ascertaining their condition, be pronounced to be generally good and sound, but some analyses of the subsoil water only just completed point so strongly to a leakage of sewage into the subsoil that I suspect there may be some defects which have not yet been discovered. Whether this is so or not can only be ascertained in one of two ways.

The first way is by laying bare the entire length of the drains. This method is practically out of the question, as there are altogether nearly three miles of drains, some of them laid at great depths.

Method proposed to be adopted to discover defects

The second way is by applying the water test to the drains and only laying them bare where this water-test shows there is leakage. This test cannot be carried out in the present condition of affairs, on account of the quantity of sewage constantly coming down the drains, but it could be effected by making special arrangements and shifting some of the men about so that no sewage should be sent down certain portions of the drains while they are under test. This is the course which I am about to adopt to localise the cause of the pollution of the subsoil water.

Falls of drains.

The vast majority of the drains are laid with very good falls, and are what is known as self-cleansing, i.e., are kept clean by the flow of sewage which ordinarily passes through them. There are, however, a few subsidiary drains which have not sufficient fall to be self-cleansing, and which, therefore, retain deposit. In two cases the main drains in Arbour Hill were found to contain a large quantity of road washings. This accumulation was not due, however, to insufficient fall in the drain, but to want of proper provision for intercepting the road washings.

Manholes.

It will be seen from the plan that there are a number of manholes on the drains for access to them. This is a good feature, but the number of manholes is not sufficient to give thorough command of the drains. In addition to this the details of the manholes are not always well arranged. The coverings are in most cases formed by very heavy stones, and some of the bottoms of the manholes are badly constructed.

Disconnection of main drains.

Three of the main drains are "disconnected" from the outfalls across the esplanade by ventilated traps fixed in manholes. This is a proper arrangement, but one of the traps, viz., that in the manhole in Laffey Street, is not a good form of trap, though on account of the large flow of water it keeps itself fairly clean. Two main drains are not "disconnected."

The main drains discharge directly into the Liffey without tidal flaps at their mouths. It has been suggested that the omission of flaps is a defect, but I cannot take this view of it, assuming all the main drains to be "disconnected." There are no doubt cases where tidal flaps are advantageous, but this is, in my opinion, not one of them; and if not required they are better omitted, as they are liable to become fixed and obstruct the sewage. The flap would not prevent the rising of the water in the drains when the tide rises, as when the flap was closed the sewage coming down the drains would collect as fast as the tide rose. On the other hand the flaps would not be required to prevent the wind blowing up the drains to the barracks, as the disconnecting traps would prevent this.

Omission of tidal flaps.

I have carefully investigated the question of the backing up of the sewage in the main drains due to the rise of the tide, and find that the backing up never under any circumstances extends beyond the road at the north side of the Esplanade, so that it does not affect the barracks.

Influence of tide on main drains.

There is one point, however, which is not quite satisfactory, viz., that on the occasions of extremely high tides in the Liffey it is possible that the ventilating shafts at the north side of the Esplanade may be closed in the case of two of the main drains. From my own observation I know that this does not take place in case of an ordinary spring tide, but from information given me as to the height to which the river occasionally rises when a great flood and a high spring tide occur at the same time it appears to me that the ventilators in question must then be closed. This danger, however, can very easily be obviated by putting in an additional ventilator a little higher up the drains.

This brings me to the question of the ventilation of the drains. The arrangements for ventilating the drains have latterly undergone a considerable change in accordance with the recommendations in the Report of Sir Charles Cameron's Commission. It appears that a number of ventilators on the course of the drains have been closed, and large brick ventilating shafts like chimneys have been constructed at the heads of the principal drains with a few intermediate pipes. The only ventilators terminating by gratings at the surface of the ground are those in the Esplanade and two in Arbour Hill.

Ventilation of drains.

From an examination of Plan (1) on which the ventilators are marked by a letter V, it will be seen that there are no ventilators on the main drains between the gratings in the esplanade and the shafts at the Arbour Hill Road, a distance of nearly 700 feet. In Arbour Hill the distances are less, but even here they are generally from 400 to 600 feet. In the case of the hospital drain there is no ventilator between the Hospital and the Esplanade, a distance of more than 1,600 feet. Many important branch drains are not ventilated at all.

The amount of ventilation thus provided appeared to me to be altogether inadequate, and this opinion was confirmed by the observations which were subsequently made. In the first place smoke was produced in the manholes in the esplanade to see whether there was any current of air either into or out of the barrack drains, but no such current could be detected, although the experiments were repeated on several occasions. In the next place the several manholes within the barrack area were opened in succession, and smoke was generated in each, and it was not until the manholes near the ventilating shafts were reached that there was any upward current of air in the drains. Observations were also made to ascertain if there was any current of air in the reverse direction (down the drains), but none could be detected. Further confirmation of the insufficiency of the ventilation was afforded by the fact that when the manholes were first opened the drains were found to smell offensively, whereas, when the manholes had been opened a short time so as to afford additional ventilation, the smell ceased.

While making the excavations for my detailed examination, three or four old drains were discovered, these were of masonry unconnected with the existing system, and all were clean except one, which was a small one close to some stables, and had some liquid stable manure in it. I also had a large old culvert, which was known to exist under the terrace in front of Royal Square, opened up and investigated. It was found to contain a considerable quantity of deposit which, on examination, proved to be clean dry earth without the slightest smell. The smoke test was applied, but no connexion with any other drain or with any building could be traced.

Old disused drains and cesspools.

Special inquiries were made about certain cesspools and pits which were reported to have existed a number of years ago in different parts of the barracks, but none of the information obtained was sufficiently definite to justify any further excavation being made in search of them.

The examination of the latrines, waterclosets, sinks, baths, and other sanitary appliances has been carried out in great detail, every one of them having been examined separately.

Sanitary Appliances. Results of examination. Situation of waterclosets, &c.

The first point that struck me in my examination was the extent to which the sanitary appliances were placed in detached out-buildings, and how few there were within the buildings,

considering the extent of the barracks and the number of the occupants. This is, of course, in a great measure explained by the fact that nearly the whole of the occupants are single men, but it is certainly a very good feature from a sanitary point of view.

Indoor water closets.

The waterclosets which are within the buildings are all well situated against outer walls and the soil pipes are all placed outside the buildings. In every case these soil pipes are "disconnected" at their foot from the drains by a ventilated trap, and are continued up full size above the roof for ventilation. These are all good arrangements. I tested the motion of the air in all the soil pipes and found that there was a current up the pipes from the fresh air inlets, as there should be. Two of the disconnecting traps were found to be choked, but this stoppage had evidently only recently occurred, and was at once removed. I think, however, that the stoppage may have been partly due to the fact that the form of trap that was used was not altogether the best.

The apparatus of the indoor closets, with the exception of two which are condemned for removal, is all good, or at any rate fairly so. The closets are mostly of the "wash-out" or of the "hopper" class with separate flushing cisterns. The details of the way in which the waterclosets are fixed are, however, generally bad. The floors beneath the basins instead of being cemented, covered with lead, or in other ways made impervious, are simply of wood. The consequence is that as slops are poured down the closets the wooden floors are liable to become saturated with urine and give off offensive smell. In addition to this the woodwork of the seat, &c. is permanently fixed, so that the space beneath is never examined and cleaned. The under side of the seat also becomes saturated with urine.

Waterclosets at the hospital.

These defective details were specially noticeable in the Arbour Hill Hospital, where of all places the sanitary arrangements ought to be most perfect. One of the closets which is used as a slop sink for the disposal of the excreta of enteric fever patients and for emptying the disinfecting liquid in which infected linen has been steeped was found in a particularly filthy condition. I was informed that this closet was also used by the enteric fever patients, and the whole arrangement struck me as most objectionable. One of the other closets at the hospital was stopped up, and all of them smelted badly from the saturation of the woodwork.

Waterclosets in outbuildings.

The waterclosets, which are in detached outbuildings, are chiefly for the use of the men, and were formerly, for the most part, "trough latrines." These have, however, all been removed in accordance with the recommendations of Sir Charles Cameron's Commission, and have been replaced chiefly by separate watercloset basins and, in a few cases, by an improved form of trough closet. The separate waterclosets are of the "wash-out" or "hopper" type, but of almost every shape and kind, and flushed by as many different kinds of flushing cisterns. On the whole the apparatus is good, but some of it is barely passable. It is only fair to state that the object of this great diversity of apparatus was to ascertain by trial which were the most suitable forms for the purpose. After the trial which has been given, I should think there would be no difficulty in eliminating the unsuitable ones. The improved trough closets which have been fixed seem to be fairly satisfactory, though in one case a self-acting flushing cistern which has been provided does not work.

When examining the outdoor waterclosets, I was struck by the numerous instances in which the seats and floors were wet; and on making inquiries this appeared to be owing to the way in which the closets are cleaned. It seems that the "fatigue party," which are told off each day to attend to these matters, do their work in the roughest possible way, the great idea apparently being to use enough water, and this is swabbed about with a mop on the floors, in the basins, and on the seats promiscuously without any subsequent drying. The result is that a great number of seats are rarely fit to sit upon, so that it is not to be wondered at that the men frequently prefer to stand on them. The closets at the school were particularly bad in this respect, and their condition was aggravated by the want of sufficient light, the place being almost in darkness.

Ablution rooms and bath-rooms.

The ablution rooms generally are fairly well situated and lighted. The same, however, cannot be said of the bath-rooms. These are mostly compartments partitioned off the ablution rooms, and are generally so dark as to repel rather than to invite use; in fact some of them have been used as occasional urinals. One of the most objectionable bath-rooms is on the south side of Horse Square. This was recommended for removal by the Barracks and Hospitals Improvements Commission, 1861, and is one of the items which I have previously stated was omitted to be carried out. The new ablution and bath-rooms in the Royal Square are great improvements on the older ones, and may with advantage be copied in future alterations.

Waste and discharge pipes.

The discharge pipes from ablution and bath-rooms and the waste pipes from sinks are properly disconnected from the drains. The waste pipes of most of the sinks, however, are not trapped in themselves. The consequence is that air from the outside is drawn into the

buildings through the waste pipe, and becomes contaminated by contact with the foul interior of the pipe, so that it frequently causes smells.

The waste pipes are usually made to discharge into channels instead of directly into gullies, and this is a good plan if the channels are not too long, but in some cases the channels are so long that there is danger of their becoming obstructed, and the waste water flowing over the ground.

A great variety of gully traps are provided for the reception of waste and surface water, and many of these are wholly unsuited for the purpose for which they are fixed. The gully traps of "D" form and of the "sanitary pattern" are objectionable, as they necessitate the provision of a small pit below, in which filth collects, and which is not accessible. The "Dip" or "Masons" trap also becomes foul when used to receive waste water. The gullies which receive surface water are in many cases too small, so that they allow silt from the roads and surfaces to pass into the drains. Gully traps.

The greater number of the rainwater pipes are "disconnected" by discharging into the surface channels. A few discharge into the water tanks under the Squares, but in these cases the overflow pipes of the tanks have open ends. Rain-water pipes.

Recommendations as to Drainage and Sanitary Appliances.

My investigation, as I explained on page 3, is not yet completed, and I am, therefore, unable to draw any general conclusions or make any complete recommendations with reference to it, but I am in a position to give a number of recommendations as to improvements which may be effected in the drainage and sanitary appliances, and this I will now do.

(1.) The portion of the main drain in Arbour Hill near the infirmary stables, and of that passing through the prison yards, which contain an accumulation of road washings, should be cleaned out. The gullies also on the lines of these drains which take surface water should be examined, and those which are found to be unsuitable should be removed and be replaced by proper ones, and silt wells constructed where necessary.

(2.) The defects mentioned on page 10 which have not yet been remedied should be remedied. These I believe to be the subsidiary drains in Arbour Hill, which are laid with hardly any fall, and the hole in the bottom of the pipe in the manhole on the north side of the Esplanade on drain No. 3.

(3.) Additional manholes should be constructed at selected places, and all manholes should have iron doors of a suitable kind instead of stone covers.

(4.) Main drains 2 and 3 should have proper disconnecting traps inserted in the manholes at the north side of the esplanade.

(5.) The ventilators of the manholes at the north side of the esplanade, on main drains Nos. 1 and 3, should be altered so as to make sure they are not closed by extremely high tides in the Liffey.

(6.) The number of ventilators on the courses of the drains should be considerably increased. The positions of the new ones can only be determined after careful consideration on the spot. I should prefer some of them to be at low level, but the drains are badly situated for this, so that it may not be possible to arrange it. The high level ventilators should of course be fixed in positions in which they will not be open to the objections that those were which were removed in accordance with the recommendations in Sir Charles Cameron's Commission.

(7.) All old disused drains, whether lately discovered or known to exist for a long while, should be entirely removed, together with all connexions. Instructions should also be given to the Royal Engineer in charge, that any old drains which may be found in future should be followed up and obliterated, instead of being simply covered in again as has sometimes been the case.

(8.) All waterclosets situated on wooden floors should either have lead trays provided beneath them, with the outlet discharging into the open air, or the floors should be concreted or otherwise made impervious. The seats of all closets should be hinged to allow of easy access to the space underneath, and the under side of the seats should be painted so as to render the wood impervious. Where the closets are likely to be tampered with special provision must be made by a lock or otherwise to secure the seat. Where risers are fixed they should also be movable. All saturated woodwork should be removed.

(9.) In the Hospital, in addition to the improvements in the waterclosets in accordance with the above recommendations, special slop sinks should be provided, so that slops may be emptied down them instead of down the closets. There are good situations for these in the small rooms opposite the waterclosets on each floor. The details of these slop sinks

should be carefully considered; porcelain ones with flushing rims would probably be the best, and there should be arrangements for washing bed-pans.

(10.) The unsuitable forms of apparatus should be eliminated from amongst the water-closets, and in future only the best forms should be selected.

(11.) Good light should be provided for the school water-closets. This could probably best be effected by introducing skylights in the roof.

(12.) Steps must be taken to improve the bath-rooms. Either good light must be provided for each of the present bath compartments or else the number of the compartments must be considerably reduced and new baths provided elsewhere. Where the channels in the floors are deep they should be covered with perforated iron or slate covers.

(13.) The waste pipes of all sinks, fixed lavatory basins, and similar appliances should be trapped in themselves either by a syphon trap or one of equally good description.

(14.) Wherever gully traps of the "D" form, "sanitary pattern," or "Dip" or "Nelson's" traps take waste water they should be removed and gully traps of a self-cleansing form be substituted. The surface water gullies which are too small should be removed and larger ones substituted, so as to prevent silt from passing into the drains.

(15.) Those overflow pipes of the water tanks under the Squares which are at present connected directly with the drains should be made to discharge with open ends.

(16.) Steps should be taken to ensure that the cleaning of all outdoor water-closets is effected in a way that will leave them in a fit state for use. Within the last month or so a man has been appointed, whose sole duty it is to look after the water-closets in the Royal Barracks, and this had a very beneficial effect. I think this system might be extended with advantage to Arbour Hill.

Nature and Stratification of Subsoil.

This question is one about which there has been a great deal of difference of opinion. On the one hand there are statements that the subsoil is more or less water-logged, and frequent recommendations that thorough subsoil drainage should be carried out. On the other hand there are statements that the subsoil is not water-logged, but is generally a clean, dry gravel. Under these circumstances the only course open to me was to ascertain beyond doubt what was the true condition of the subsoil in the different parts of the barracks.

I therefore had a large number of deep trial holes dug all over the site of the barracks, in addition to some which had previously been made by the Royal Engineers. The positions of these holes are shown by green circles on Plan (II.) appended hereto. I have also had sections prepared on four different lines through the barracks to show the results arrived at by the trial holes, which are numbered to correspond with the number on the plan. These sections are marked (III.)

One remarkable fact soon became apparent, namely, that instead of meeting with water readily, as one would naturally expect where the question of water-logging had been raised, the difficulty was to find any water at all. In fact it was necessary to sink the holes to such a great depth before water was met with that the larger number of the holes were stopped before they came to water. The least depth at which the water was met with was about 12 feet below the surface of the barrack area, and the greatest depth 28 feet. On the other hand the greatest depth of the foundations of the buildings (which are shown by dotted black lines on the sections) is only 7 feet, and the general depth much less. It is clear, therefore, that the subsoil water is everywhere at such a depth below the foundations that it cannot affect them.

Another remarkable circumstance that shows the dryness of the site of the Royal Barracks is that where subsoil drains have been laid round certain blocks of buildings no water ever runs from the outlets, as can readily be seen, as these are visible.

It is also especially worthy of note that the level of the subsoil water at the south of the barrack area and in the Esplanade is lower than the average level of the water in the Liffey, and is not in any way affected by the rise and fall of the tide in the Liffey.

As the sequence of the strata disclosed by the holes was not clear, I consulted Professor Hull, F.R.S., Director of the Geological Survey of Ireland, and he kindly visited the Royal Barracks and examined a number of trial holes with me. He explained what were his views on the subject, and subsequently wrote a memorandum on the nature of the subsoil and stratification of the site of the Royal Barracks, accompanied by a generalised section of the stratification. Copies of both of these are appended hereto.

From the sections which I have prepared, and from Professor Hull's memorandum, it will be seen that the strata underneath the barracks consist chiefly of coarse gravel over an underlying deposit of boulder clay. This boulder clay, which is close to the surface in Arbour Hill and in portions of the upper part of the barrack area, slopes southwards and passes below the gravel in question. Both the gravel and boulder clay are dry.

The formation below the Esplanade is entirely different from that below the Barracks, and consists of an estuarial deposit, chiefly of hard river mud, overlaying a clean water-bearing chalk. As already stated, the level of this subsoil water is below the average level of the water in the Liffey, and is not affected by the rise and fall of the tide. This shows that the subsoil water in the Esplanade cannot be in connexion with the river.

It will be noticed that on Section CD two levels of subsoil water are shown in trial hole No 17, one at 13 feet below the surface, and one at 5 feet below the surface. The explanation is as follows:—This hole was sunk through hard clay which was perfectly dry to a depth of 13 feet, at which point water was suddenly met with which gradually rose up to the higher level. This water is quite distinct from the subsoil water beneath the barracks, as it is of an artesian nature and only rises up when liberated from under the boulder clay by a hole or well sunk to a considerable depth through the clay. The other trial holes, which were sunk on the north side of the barracks, were quite dry. No doubt the supply to two of the wells at the north of the barracks and to some of those in Arbour Hill can be accounted for in the same way.

Artesian nature of some of subsoil water.

As the facts above stated appeared to be inconsistent with the observations in the Report of Sir Charles Cameron's Commission as to the retaining walls at the north of the barracks being kept damp by the passage of water from the higher to the lower ground, I specially investigated this point. I easily found the walls referred to, and there could be no question as to their dampness, but on leaving a deep excavation made at the back of the westest of the walls I found that the water came from the public road and not from the subsoil of Arbour Hill. At the point in question there is no channel or gully provided, as there should be, to take the surface water from the road, and it collects in pools just opposite the westest part of the wall. Examinations also showed that surface water collected in a similar way at the back of other wet walls to the north of the barracks. I have no doubt that this is the explanation of the dampness of the retaining walls; at any rate, it is certain that there is so large amount of water passing from Arbour Hill to the subsoil immediately under the Royal Barracks as has been imagined.

Cause of damp retaining walls.

On the assumption that water was constantly passing in this way to the barracks a subsoil drain KK on Plan (II.), 18 to 24 feet deep, has quite recently been constructed along the south side of the Arbour Hill property, so as to intercept the water from Arbour Hill, and prevent it passing into the barracks. The boulder clay, however, through which this subsoil drain was cut was dry, and the only places in which water was met with were here and there in potholes of gravel, or similar material, so that notwithstanding that the deep drains of the burial ground were connected with this subsoil drain, comparatively little water is discharged by it.

Subsoil drains.

On the other hand, a shallower subsoil drain LL on Plan (II.), that has been constructed alongside the hospital drain, through the married soldiers' quarters and Governor's garden in Arbour Hill, has a considerable run of water down it, coming from potholes of gravel.

I should mention that all the subsoil drains with the exception of that marked KK, discharge with open ends, as they should do. This latter drain, however, is connected directly with the main sewage drain (No. 1) which is an improper arrangement.

The general conclusion to be drawn from my investigation of the subsoil is that the site of the barracks is in no way water-logged, but, on the contrary, is remarkably dry, and affords a good foundation for the buildings.

General conclusion.

Recommendations as to Subsoil Drainage.

The only recommendations I have to make in connexion with this subject are the following:—

(1.) That the thorough subsoil drainage of the whole site of the barracks which was recommended in the Report of Sir Charles Cameron's Commission, and has not yet been carried out, be omitted.

(2.) That the Corporation of Dublin be communicated with and requested to provide the necessary surface water channels and gullies in the Arbour Hill Road, at the north of the Royal Barracks, to prevent the water collecting against the back of the retaining walls.

(3.) That the subsoil drain from Arbour Hill marked KK, be "disconnected" at its lower end from the sewage drains.

I have, &c.

4, Westminster Chambers,
Victoria Street, London, S.W.,
25th February 1889.

ROGERS FIELD,
M. Inst. C.E.

APPENDIX.

MEMORANDUM ON the NATURE of the SUBSOIL and STRATIFICATION of the SITE of the ROYAL BARRACKS, DUBLIN, by Professor HULL, LL.D., F.R.S., Director of the Geological Survey of Ireland.

At the request of Mr. Rogers Field, Government Commissioner, appointed to report upon the sanitary condition of the Royal Barracks, I examined several deep pits and other excavations, some of which had been specially made to determine the nature of the subsoil and stratification under the barrack area, with a view of determining whether any cause of fever or unhealthiness could be traced to the ground on which the barracks are built; and I now desire to record my impression as regards this question.

The buildings are laid out on a terrace, slightly sloping towards the valley of the Liffey, and bounded inwards by an abrupt ascent of about 15 or 20 feet leading up to Arbour Hill, on which are erected the gaol and chapel. At the foot of the terrace containing the buildings an alluvial flat or esplanade extends from the barrack wall to the river bank or wall, along which runs the high road to the park.

(1.) The stratification of the esplanade is quite independent of that forming the foundation of the barrack buildings, and consists of the following:—

(1.) Stratification of esplanade—

	Ft.	In.
(a) Made ground, gravel, &c.	3	6
(b) Dark mud or silt, laminated and stony at bottom	8	6
(c) Clean ballast, gravel with water (bottom not reached)	2	0
Total	14	0

The water in the gravel is disconnected from that of the river, as it does not rise and fall with the ebb and flow of the tide; this is owing to the intervention of the impervious dark silt.

The strata forming the river valley and esplanade occupy a natural trench, or ancient river valley, eroded out of the drift deposits forming the terrace of the barrack area, against which they terminate inland, as shown in the section herewith sent.

(2.) The strata of the barrack area consist of two varieties; first, coarse clayey gravel extending from the lower barrack wall upwards towards the foot of Arbour Hill, but giving place to an underlying deposit of boulder clay, which extends all along the upper part of the barrack area and sloping southwards passes below the gravel. None of the trenches (as far as I saw) pass from the gravel down into the boulder clay, but the general relations of these two deposits can scarcely be doubted, and are represented on the accompanying section. The boulder clay is impervious to water, but at the cavalry stables one or more wells have been sunk down through the boulder clay into a water-bearing stratum, presumably sand or gravel, to a depth of 13 feet, and the water ascends to within 2½ or 5 feet of the present ground on the artesian principle; the boulder clay extends under Arbour Hill, and, as I am informed, was not passed through in the trench 25 feet in depth, which runs along in front of the gaol wall.

Both the boulder clay and the gravel are dry, and may be considered as affording a good foundation for the buildings. I have seen nothing to indicate that the ground is saturated with sewage matter, or that it was extensively used for buildings or cottages before being laid out as barracks.* The subsoil appears but little disturbed, and free from extraneous matter, and, as the general result of my examination, I have come to the conclusion that whatever else may be the cause of unhealthiness, it does not arise from the character of the subsoil on which the barracks are built.

(Signed) EDWARD HULL.

Geological Survey Office, Dublin,
5th February 1859.

* These were commenced as far back as 1704.

It commencing 28° Royal Field's Street about 12° February 1877



PLAN SEVEN DUNDEE. TOWN HOUSES AND GARDENS
AT THE ROYAL BARRACKS AND ARCADE HILL DUNDEE

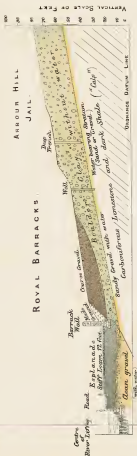
Reproduced by the Royal Public Works Office, 1877, Edinburgh, 1887.



Scale of Feet and Inches. 1/4" = 10 Feet. 1/2" = 20 Feet. 3/4" = 30 Feet. 1" = 40 Feet. 1 1/4" = 50 Feet. 1 1/2" = 60 Feet. 1 3/4" = 70 Feet. 2" = 80 Feet. 2 1/4" = 90 Feet. 2 1/2" = 100 Feet. 2 3/4" = 110 Feet. 3" = 120 Feet. 3 1/4" = 130 Feet. 3 1/2" = 140 Feet. 3 3/4" = 150 Feet. 4" = 160 Feet. 4 1/4" = 170 Feet. 4 1/2" = 180 Feet. 4 3/4" = 190 Feet. 5" = 200 Feet. 5 1/4" = 210 Feet. 5 1/2" = 220 Feet. 5 3/4" = 230 Feet. 6" = 240 Feet. 6 1/4" = 250 Feet. 6 1/2" = 260 Feet. 6 3/4" = 270 Feet. 7" = 280 Feet. 7 1/4" = 290 Feet. 7 1/2" = 300 Feet. 7 3/4" = 310 Feet. 8" = 320 Feet. 8 1/4" = 330 Feet. 8 1/2" = 340 Feet. 8 3/4" = 350 Feet. 9" = 360 Feet. 9 1/4" = 370 Feet. 9 1/2" = 380 Feet. 9 3/4" = 390 Feet. 10" = 400 Feet. 10 1/4" = 410 Feet. 10 1/2" = 420 Feet. 10 3/4" = 430 Feet. 11" = 440 Feet. 11 1/4" = 450 Feet. 11 1/2" = 460 Feet. 11 3/4" = 470 Feet. 12" = 480 Feet. 12 1/4" = 490 Feet. 12 1/2" = 500 Feet. 12 3/4" = 510 Feet. 13" = 520 Feet. 13 1/4" = 530 Feet. 13 1/2" = 540 Feet. 13 3/4" = 550 Feet. 14" = 560 Feet. 14 1/4" = 570 Feet. 14 1/2" = 580 Feet. 14 3/4" = 590 Feet. 15" = 600 Feet. 15 1/4" = 610 Feet. 15 1/2" = 620 Feet. 15 3/4" = 630 Feet. 16" = 640 Feet. 16 1/4" = 650 Feet. 16 1/2" = 660 Feet. 16 3/4" = 670 Feet. 17" = 680 Feet. 17 1/4" = 690 Feet. 17 1/2" = 700 Feet. 17 3/4" = 710 Feet. 18" = 720 Feet. 18 1/4" = 730 Feet. 18 1/2" = 740 Feet. 18 3/4" = 750 Feet. 19" = 760 Feet. 19 1/4" = 770 Feet. 19 1/2" = 780 Feet. 19 3/4" = 790 Feet. 20" = 800 Feet. 20 1/4" = 810 Feet. 20 1/2" = 820 Feet. 20 3/4" = 830 Feet. 21" = 840 Feet. 21 1/4" = 850 Feet. 21 1/2" = 860 Feet. 21 3/4" = 870 Feet. 22" = 880 Feet. 22 1/4" = 890 Feet. 22 1/2" = 900 Feet. 22 3/4" = 910 Feet. 23" = 920 Feet. 23 1/4" = 930 Feet. 23 1/2" = 940 Feet. 23 3/4" = 950 Feet. 24" = 960 Feet. 24 1/4" = 970 Feet. 24 1/2" = 980 Feet. 24 3/4" = 990 Feet. 25" = 1000 Feet. 25 1/4" = 1010 Feet. 25 1/2" = 1020 Feet. 25 3/4" = 1030 Feet. 26" = 1040 Feet. 26 1/4" = 1050 Feet. 26 1/2" = 1060 Feet. 26 3/4" = 1070 Feet. 27" = 1080 Feet. 27 1/4" = 1090 Feet. 27 1/2" = 1100 Feet. 27 3/4" = 1110 Feet. 28" = 1120 Feet. 28 1/4" = 1130 Feet. 28 1/2" = 1140 Feet. 28 3/4" = 1150 Feet. 29" = 1160 Feet. 29 1/4" = 1170 Feet. 29 1/2" = 1180 Feet. 29 3/4" = 1190 Feet. 30" = 1200 Feet. 30 1/4" = 1210 Feet. 30 1/2" = 1220 Feet. 30 3/4" = 1230 Feet. 31" = 1240 Feet. 31 1/4" = 1250 Feet. 31 1/2" = 1260 Feet. 31 3/4" = 1270 Feet. 32" = 1280 Feet. 32 1/4" = 1290 Feet. 32 1/2" = 1300 Feet. 32 3/4" = 1310 Feet. 33" = 1320 Feet. 33 1/4" = 1330 Feet. 33 1/2" = 1340 Feet. 33 3/4" = 1350 Feet. 34" = 1360 Feet. 34 1/4" = 1370 Feet. 34 1/2" = 1380 Feet. 34 3/4" = 1390 Feet. 35" = 1400 Feet. 35 1/4" = 1410 Feet. 35 1/2" = 1420 Feet. 35 3/4" = 1430 Feet. 36" = 1440 Feet. 36 1/4" = 1450 Feet. 36 1/2" = 1460 Feet. 36 3/4" = 1470 Feet. 37" = 1480 Feet. 37 1/4" = 1490 Feet. 37 1/2" = 1500 Feet. 37 3/4" = 1510 Feet. 38" = 1520 Feet. 38 1/4" = 1530 Feet. 38 1/2" = 1540 Feet. 38 3/4" = 1550 Feet. 39" = 1560 Feet. 39 1/4" = 1570 Feet. 39 1/2" = 1580 Feet. 39 3/4" = 1590 Feet. 40" = 1600 Feet. 40 1/4" = 1610 Feet. 40 1/2" = 1620 Feet. 40 3/4" = 1630 Feet. 41" = 1640 Feet. 41 1/4" = 1650 Feet. 41 1/2" = 1660 Feet. 41 3/4" = 1670 Feet. 42" = 1680 Feet. 42 1/4" = 1690 Feet. 42 1/2" = 1700 Feet. 42 3/4" = 1710 Feet. 43" = 1720 Feet. 43 1/4" = 1730 Feet. 43 1/2" = 1740 Feet. 43 3/4" = 1750 Feet. 44" = 1760 Feet. 44 1/4" = 1770 Feet. 44 1/2" = 1780 Feet. 44 3/4" = 1790 Feet. 45" = 1800 Feet. 45 1/4" = 1810 Feet. 45 1/2" = 1820 Feet. 45 3/4" = 1830 Feet. 46" = 1840 Feet. 46 1/4" = 1850 Feet. 46 1/2" = 1860 Feet. 46 3/4" = 1870 Feet. 47" = 1880 Feet. 47 1/4" = 1890 Feet. 47 1/2" = 1900 Feet. 47 3/4" = 1910 Feet. 48" = 1920 Feet. 48 1/4" = 1930 Feet. 48 1/2" = 1940 Feet. 48 3/4" = 1950 Feet. 49" = 1960 Feet. 49 1/4" = 1970 Feet. 49 1/2" = 1980 Feet. 49 3/4" = 1990 Feet. 50" = 2000 Feet. 50 1/4" = 2010 Feet. 50 1/2" = 2020 Feet. 50 3/4" = 2030 Feet. 51" = 2040 Feet. 51 1/4" = 2050 Feet. 51 1/2" = 2060 Feet. 51 3/4" = 2070 Feet. 52" = 2080 Feet. 52 1/4" = 2090 Feet. 52 1/2" = 2100 Feet. 52 3/4" = 2110 Feet. 53" = 2120 Feet. 53 1/4" = 2130 Feet. 53 1/2" = 2140 Feet. 53 3/4" = 2150 Feet. 54" = 2160 Feet. 54 1/4" = 2170 Feet. 54 1/2" = 2180 Feet. 54 3/4" = 2190 Feet. 55" = 2200 Feet. 55 1/4" = 2210 Feet. 55 1/2" = 2220 Feet. 55 3/4" = 2230 Feet. 56" = 2240 Feet. 56 1/4" = 2250 Feet. 56 1/2" = 2260 Feet. 56 3/4" = 2270 Feet. 57" = 2280 Feet. 57 1/4" = 2290 Feet. 57 1/2" = 2300 Feet. 57 3/4" = 2310 Feet. 58" = 2320 Feet. 58 1/4" = 2330 Feet. 58 1/2" = 2340 Feet. 58 3/4" = 2350 Feet. 59" = 2360 Feet. 59 1/4" = 2370 Feet. 59 1/2" = 2380 Feet. 59 3/4" = 2390 Feet. 60" = 2400 Feet. 60 1/4" = 2410 Feet. 60 1/2" = 2420 Feet. 60 3/4" = 2430 Feet. 61" = 2440 Feet. 61 1/4" = 2450 Feet. 61 1/2" = 2460 Feet. 61 3/4" = 2470 Feet. 62" = 2480 Feet. 62 1/4" = 2490 Feet. 62 1/2" = 2500 Feet. 62 3/4" = 2510 Feet. 63" = 2520 Feet. 63 1/4" = 2530 Feet. 63 1/2" = 2540 Feet. 63 3/4" = 2550 Feet. 64" = 2560 Feet. 64 1/4" = 2570 Feet. 64 1/2" = 2580 Feet. 64 3/4" = 2590 Feet. 65" = 2600 Feet. 65 1/4" = 2610 Feet. 65 1/2" = 2620 Feet. 65 3/4" = 2630 Feet. 66" = 2640 Feet. 66 1/4" = 2650 Feet. 66 1/2" = 2660 Feet. 66 3/4" = 2670 Feet. 67" = 2680 Feet. 67 1/4" = 2690 Feet. 67 1/2" = 2700 Feet. 67 3/4" = 2710 Feet. 68" = 2720 Feet. 68 1/4" = 2730 Feet. 68 1/2" = 2740 Feet. 68 3/4" = 2750 Feet. 69" = 2760 Feet. 69 1/4" = 2770 Feet. 69 1/2" = 2780 Feet. 69 3/4" = 2790 Feet. 70" = 2800 Feet. 70 1/4" = 2810 Feet. 70 1/2" = 2820 Feet. 70 3/4" = 2830 Feet. 71" = 2840 Feet. 71 1/4" = 2850 Feet. 71 1/2" = 2860 Feet. 71 3/4" = 2870 Feet. 72" = 2880 Feet. 72 1/4" = 2890 Feet. 72 1/2" = 2900 Feet. 72 3/4" = 2910 Feet. 73" = 2920 Feet. 73 1/4" = 2930 Feet. 73 1/2" = 2940 Feet. 73 3/4" = 2950 Feet. 74" = 2960 Feet. 74 1/4" = 2970 Feet. 74 1/2" = 2980 Feet. 74 3/4" = 2990 Feet. 75" = 3000 Feet. 75 1/4" = 3010 Feet. 75 1/2" = 3020 Feet. 75 3/4" = 3030 Feet. 76" = 3040 Feet. 76 1/4" = 3050 Feet. 76 1/2" = 3060 Feet. 76 3/4" = 3070 Feet. 77" = 3080 Feet. 77 1/4" = 3090 Feet. 77 1/2" = 3100 Feet. 77 3/4" = 3110 Feet. 78" = 3120 Feet. 78 1/4" = 3130 Feet. 78 1/2" = 3140 Feet. 78 3/4" = 3150 Feet. 79" = 3160 Feet. 79 1/4" = 3170 Feet. 79 1/2" = 3180 Feet. 79 3/4" = 3190 Feet. 80" = 3200 Feet. 80 1/4" = 3210 Feet. 80 1/2" = 3220 Feet. 80 3/4" = 3230 Feet. 81" = 3240 Feet. 81 1/4" = 3250 Feet. 81 1/2" = 3260 Feet. 81 3/4" = 3270 Feet. 82" = 3280 Feet. 82 1/4" = 3290 Feet. 82 1/2" = 3300 Feet. 82 3/4" = 3310 Feet. 83" = 3320 Feet. 83 1/4" = 3330 Feet. 83 1/2" = 3340 Feet. 83 3/4" = 3350 Feet. 84" = 3360 Feet. 84 1/4" = 3370 Feet. 84 1/2" = 3380 Feet. 84 3/4" = 3390 Feet. 85" = 3400 Feet. 85 1/4" = 3410 Feet. 85 1/2" = 3420 Feet. 85 3/4" = 3430 Feet. 86" = 3440 Feet. 86 1/4" = 3450 Feet. 86 1/2" = 3460 Feet. 86 3/4" = 3470 Feet. 87" = 3480 Feet. 87 1/4" = 3490 Feet. 87 1/2" = 3500 Feet. 87 3/4" = 3510 Feet. 88" = 3520 Feet. 88 1/4" = 3530 Feet. 88 1/2" = 3540 Feet. 88 3/4" = 3550 Feet. 89" = 3560 Feet. 89 1/4" = 3570 Feet. 89 1/2" = 3580 Feet. 89 3/4" = 3590 Feet. 90" = 3600 Feet. 90 1/4" = 3610 Feet. 90 1/2" = 3620 Feet. 90 3/4" = 3630 Feet. 91" = 3640 Feet. 91 1/4" = 3650 Feet. 91 1/2" = 3660 Feet. 91 3/4" = 3670 Feet. 92" = 3680 Feet. 92 1/4" = 3690 Feet. 92 1/2" = 3700 Feet. 92 3/4" = 3710 Feet. 93" = 3720 Feet. 93 1/4" = 3730 Feet. 93 1/2" = 3740 Feet. 93 3/4" = 3750 Feet. 94" = 3760 Feet. 94 1/4" = 3770 Feet. 94 1/2" = 3780 Feet. 94 3/4" = 3790 Feet. 95" = 3800 Feet. 95 1/4" = 3810 Feet. 95 1/2" = 3820 Feet. 95 3/4" = 3830 Feet. 96" = 3840 Feet. 96 1/4" = 3850 Feet. 96 1/2" = 3860 Feet. 96 3/4" = 3870 Feet. 97" = 3880 Feet. 97 1/4" = 3890 Feet. 97 1/2" = 3900 Feet. 97 3/4" = 3910 Feet. 98" = 3920 Feet. 98 1/4" = 3930 Feet. 98 1/2" = 3940 Feet. 98 3/4" = 3950 Feet. 99" = 3960 Feet. 99 1/4" = 3970 Feet. 99 1/2" = 3980 Feet. 99 3/4" = 3990 Feet. 100" = 4000 Feet. 100 1/4" = 4010 Feet. 100 1/2" = 4020 Feet. 100 3/4" = 4030 Feet. 101" = 4040 Feet. 101 1/4" = 4050 Feet. 101 1/2" = 4060 Feet. 101 3/4" = 4070 Feet. 102" = 4080 Feet. 102 1/4" = 4090 Feet. 102 1/2" = 4100 Feet. 102 3/4" = 4110 Feet. 103" = 4120 Feet. 103 1/4" = 4130 Feet. 103 1/2" = 4140 Feet. 103 3/4" = 4150 Feet. 104" = 4160 Feet. 104 1/4" = 4170 Feet. 104 1/2" = 4180 Feet. 104 3/4" = 4190 Feet. 105" = 4200 Feet. 105 1/4" = 4210 Feet. 105 1/2" = 4220 Feet. 105 3/4" = 4230 Feet. 106" = 4240 Feet. 106 1/4" = 4250 Feet. 106 1/2" = 4260 Feet. 106 3/4" = 4270 Feet. 107" = 4280 Feet. 107 1/4" = 4290 Feet. 107 1/2" = 4300 Feet. 107 3/4" = 4310 Feet. 108" = 4320 Feet. 108 1/4" = 4330 Feet. 108 1/2" = 4340 Feet. 108 3/4" = 4350 Feet. 109" = 4360 Feet. 109 1/4" = 4370 Feet. 109 1/2" = 4380 Feet. 109 3/4" = 4390 Feet. 110" = 4400 Feet. 110 1/4" = 4410 Feet. 110 1/2" = 4420 Feet. 110 3/4" = 4430 Feet. 111" = 4440 Feet. 111 1/4" = 4450 Feet. 111 1/2" = 4460 Feet. 111 3/4" = 4470 Feet. 112" = 4480 Feet. 112 1/4" = 4490 Feet. 112 1/2" = 4500 Feet. 112 3/4" = 4510 Feet. 113" = 4520 Feet. 113 1/4" = 4530 Feet. 113 1/2" = 4540 Feet. 113 3/4" = 4550 Feet. 114" = 4560 Feet. 114 1/4" = 4570 Feet. 114 1/2" = 4580 Feet. 114 3/4" = 4590 Feet. 115" = 4600 Feet. 115 1/4" = 4610 Feet. 115 1/2" = 4620 Feet. 115 3/4" = 4630 Feet. 116" = 4640 Feet. 116 1/4" = 4650 Feet. 116 1/2" = 4660 Feet. 116 3/4" = 4670 Feet. 117" = 4680 Feet. 117 1/4" = 4690 Feet. 117 1/2" = 4700 Feet. 117 3/4" = 4710 Feet. 118" = 4720 Feet. 118 1/4" = 4730 Feet. 118 1/2" = 4740 Feet. 118 3/4" = 4750 Feet. 119" = 4760 Feet. 119 1/4" = 4770 Feet. 119 1/2" = 4780 Feet. 119 3/4" = 4790 Feet. 120" = 4800 Feet. 120 1/4" = 4810 Feet. 120 1/2" = 4820 Feet. 120 3/4" = 4830 Feet. 121" = 4840 Feet. 121 1/4" = 4850 Feet. 121 1/2" = 4860 Feet. 121 3/4" = 4870 Feet. 122" = 4880 Feet. 122 1/4" = 4890 Feet. 122 1/2" = 4900 Feet. 122 3/4" = 4910 Feet. 123" = 4920 Feet. 123 1/4" = 4930 Feet. 123 1/2" = 4940 Feet. 123 3/4" = 4950 Feet. 124" = 4960 Feet. 124 1/4" = 4970 Feet. 124 1/2" = 4980 Feet. 124 3/4" = 4990 Feet. 125" = 5000 Feet. 125 1/4" = 5010 Feet. 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Feet. 161 1/4" = 6450 Feet. 161 1/2" = 6460 Feet. 161 3/4" = 6470 Feet. 162" = 6480 Feet. 162 1/4" = 6490 Feet. 162 1/2" = 6500 Feet. 162 3/4" = 6510 Feet. 163" = 6520 Feet. 163 1/4" = 6530 Feet. 163 1/2" = 6540 Feet. 163 3/4" = 6550 Feet. 164" = 6560 Feet. 164 1/4" = 6570 Feet. 164 1/2" = 6580 Feet. 164 3/4" = 6590 Feet. 165" = 6600 Feet. 165 1/4" = 6610 Feet. 165 1/2" = 6620 Feet. 165 3/4" = 6630 Feet. 166" = 6640 Feet. 166 1/4" = 6650 Feet. 166 1/2" = 6660 Feet. 166 3/4" = 6670 Feet. 167" = 6680 Feet. 167 1/4" = 6690 Feet. 167 1/2" = 6700 Feet. 167 3/4" = 6710 Feet. 168" = 6720 Feet. 168 1/4" = 6730 Feet. 168 1/2" = 6740 Feet. 168 3/4" = 6750 Feet. 169" = 6760 Feet. 169 1/4" = 6770 Feet. 169 1/2" = 6780 Feet. 169 3/4" = 6790 Feet. 170" = 6800 Feet. 170 1/4" = 6810 Feet. 170 1/2" = 6820 Feet. 170 3/4" = 6830 Feet. 171" = 6840 Feet. 171 1/4" = 6850 Feet. 171 1/2" = 6860 Feet. 171 3/4" = 6870 Feet. 172" = 6880 Feet. 172 1/4" = 6890 Feet. 172 1/2" = 6900 Feet. 172 3/4" = 6910 Feet. 173" = 6920 Feet. 173 1/4" = 6930 Feet. 173 1/2" = 6940 Feet. 173 3/4" = 6950 Feet. 174" = 6960 Feet. 174 1/4" = 6970 Feet. 174 1/2" = 6980 Feet. 174 3/4" = 6990 Feet. 175" = 7000 Feet. 175 1/4" = 7010 Feet. 175 1/2" = 7020 Feet. 175 3/4" = 7030 Feet. 176" = 7040 Feet. 176 1/4" = 7050 Feet. 176 1/2" = 7060 Feet. 176 3/4" = 7070 Feet. 177" = 7080 Feet. 177 1/4" = 7090 Feet. 177 1/2" = 7100 Feet. 177 3/4" = 7110 Feet. 178" = 7120 Feet. 178 1/4" = 7130 Feet. 178 1/2" = 7140 Feet. 178 3/4" = 7150 Feet. 179" = 7160 Feet. 179 1/4" = 7170 Feet. 179 1/2" = 7180 Feet. 179 3/4" = 7190 Feet. 180" = 7200 Feet. 180 1/4" = 7210 Feet. 180 1/2" = 7220 Feet. 180 3/4" = 7230 Feet. 181" = 7240 Feet. 18

GENERALIZED SECTION THROUGH THE ROYAL BARRACKS TO SHOW STRATIFICATION.

FROM OBSERVATIONS MADE 1ST FEBRUARY 1889.



HORIZONTAL SCALE ABOUT 30 INCHES TO ONE MILE.

(Signed) E. HULL.
5th Feb'y 1889.

